



## Five-Year Review Report

**Thermo Chem Inc. Site  
Muskegon County  
Egelston Township, Michigan**


**May, 2005**

**Prepared By:**

**U.S. EPA Region 5  
Chicago, Illinois**

Approved by:

Date:

*for*   
\_\_\_\_\_  
Richard C. Karl, Director  
Superfund Division

*5/10/05*  
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## **Five-Year Review Report**

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January 2004 Groundwater Particle Trace

June 2004 Groundwater Particle Trace

## List of Acronyms

<u>Acronym</u>	<u>Name or Term</u>
AOC	Administrative Order on Consent
ARARs	Applicable or Relevant and Appropriate Requirements
CERCLA/SARA	Comprehensive Environmental Response, Compensation and Liability Act/Superfund Amendments and Reauthorization Act of 1986 (Superfund)
CD	Consent Decree
ESD	Explanation of Significant Difference
GWETS	Groundwater Extraction Treatment System
ISVE	In-situ Soil Vapor Extraction
LDRs	Land Disposal Restrictions
LNAPL	Light Non-aqueous Phase Liquid
MDNR	Michigan Department of Natural Resources
MDEQ	Michigan Department of Environmental Quality
NPDES	National Pollution Disposal Elimination System
NPL	National Priorities List
O&M	Operation and Maintenance
OU	Operable Unit
ppb	Parts per Billion concentration
PCOR	Preliminary Close Out Report
PRP	Potential Responsible Parties
ROD	Record of Decision
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/ Feasibility Study
SOW	Statement of Work
TBC	To Be Considered
U.S. EPA	United States Environmental Protection Agency
VAS	Vertical Aquifer Sampling
VOC	Volatile Organic Compound

## Executive Summary

The purpose of a statutory five-year review is to evaluate whether a completed remedial action remains protective of human health and the environment where hazardous waste remains on-site at levels that do not allow for unlimited use and unrestricted exposure. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues found during the review, if any, and identify recommendations to address them.

U. S. EPA conducted this statutory five-year review under Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP). The next five year report is due by March 2010.

This review will be placed in the Thermo Chem Superfund Site (Site) files and local repositories for the Site at the following locations and be available for viewing during normal business hours:

Muskegon County Library  
Egelston Township Branch  
Egelston Township Hall  
5832 Apple Avenue  
Muskegon, Michigan 49442

U. S. Environmental Protection Agency  
Region 5 Records Center  
77 W. Jackson Blvd., 7-HJ  
Chicago, IL 60604

## Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name (from WasteLAN): Thermo-Chem, Inc.		
EPA ID (from WasteLAN): MID044567162		
Region: 5	State: MI	City/County: Muskegon/Muskegon
SITE STATUS		
NPL status: <input checked="" type="checkbox"/> Final <input type="checkbox"/> Deleted <input type="checkbox"/> Other (specify)		
Remediation status (choose all that apply): <input type="checkbox"/> Under Construction <input checked="" type="checkbox"/> Operating <input type="checkbox"/> Complete		
Multiple OUs? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	Construction completion date: 3/30/1999	
Has site been put into reuse? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		
REVIEW STATUS		
Lead agency: <input checked="" type="checkbox"/> EPA <input type="checkbox"/> State <input type="checkbox"/> Tribe <input type="checkbox"/> Other Federal Agency		
Author name: Kenneth Glatz		
Author title: Remedial Project Manager	Author affiliation: Superfund-RRB 2, Section 6	
Review period: March 8, 2000		
Date(s) of site inspection: Several, jointly by U.S. EPA and MDEQ. Latest 11/17/2004		
Type of review: <input checked="" type="checkbox"/> Post-SARA <input type="checkbox"/> Pre-SARA <input type="checkbox"/> NPL-Removal only <input type="checkbox"/> Non-NPL Remedial Action Site <input type="checkbox"/> NPL State/Tribe-lead <input type="checkbox"/> Regional Discretion		
Review number: <input checked="" type="checkbox"/> 1 (first) <input type="checkbox"/> 2 (second) <input type="checkbox"/> 3 (third) <input type="checkbox"/> Other (specify)		
Triggering action: <input type="checkbox"/> Actual RA Onsite Construction at OU # 1 <input type="checkbox"/> Actual RA Start at OU#1 <input type="checkbox"/> Construction Completion <input type="checkbox"/> Previous Five-Year Review Report <input checked="" type="checkbox"/> Other (specify) Remedial Action Implementation Report		
Triggering action date (from WasteLAN): March 8, 2000		
Due date (five years after triggering action date): March 8, 2005		

**Issues:**

The remedy for groundwater restoration has been in operation since 1999. Results of the monitoring data, although not conclusive, indicate progress toward achieving groundwater clean-up goals. Initially the GWETS upper aquifer extraction/treatment system was not completely capturing the plume, allowing contaminants to flow into the Black Creek floodplain. With improved preventative maintenance of the pumps, and periodic flushing of the extraction pumps and process lines, the extraction rates are now high enough to achieve hydraulic capture of the contaminated plume, intercepting the flow of contaminated groundwater to the wetlands. Data also suggests that the residual contamination in the wetlands, down gradient of the GWETS, is being reduced by natural processes. However both of these observations need to be supported by continued hydraulic and chemical monitoring.

There is some concern, based on the distance between the monitoring wells in the wetlands, that the leading edge of the wetlands plume may not be adequately monitored.

Monitoring data collected during 1998 and 1999 sampling events, and during supplemental studies by EPA KERR lab personnel from Ada, Oklahoma, indicated that there may be deep aquifer contamination which is not being captured by the GWETS.

There are residential wells in the vicinity of the Site that have the potential of being impacted by the Site plume, which are only being monitored for VOCs on an annual basis.

In the past, sampling has been conducted with bailers, and laboratory detection limits set above typical trace contaminant levels. This was done to characterize total VOC sample content, rather than trace chemical content.

**Recommendations and Follow-up Actions:**

The adequacy of hydraulic capture of contaminated groundwater by the GWETS will be evaluated on a quarterly basis by the interpretation of observed water levels and the analysis of groundwater flow directions and flow rates, to show whether the GWETS is preventing the flow of contaminants to the Black Creek floodplain. The model will be used for this analysis. Two groundwater "capture" figures are attached to this report showing paths that water particles would follow when moving through the aquifer. The Subterranean Research Inc. analysis will be performed for each groundwater monitoring event, and extraction rates adjusted as required to maintain capture of the contaminated plume.

Monitoring data will be statistically analyzed when data becomes available to show the

progress/lack of progress toward groundwater clean-up goals. In order to insure that the GWETS continues to operate as designed, and to address any detrimental change in the natural processes being observed at the Site, more monitoring wells and additional remedial activity will be considered if the results from a statistical evaluation at any monitoring well downgradient of the GWETS does not indicate a "Significant better" or "Significantly Decreasing Trend". Historical monitoring data is currently being consolidated as a starting point for this analysis. A revised monitoring program will be structured to rectify any deficiencies of the historical data necessary to perform the statistical analysis.

One additional monitoring well cluster is currently being installed in the Black Creek floodplain, and will be added to the monitoring program to improve the monitoring at the down gradient western edge of the Black Creek floodplain plume. All contaminants of concern were below analytical detection levels for the VAS phase of the well installation.

Hydraulic and chemical monitoring at the Site will continue in both the upper and lower aquifers until the groundwater meets the clean up standards shown in Table 1 throughout the plume. The monitoring schedule for the lower aquifer may be revised downward if the results of chemical monitoring in the lower aquifer indicates that the VOC content is below risk based values.

The PRPs have requested that the ISVE vapor extraction system be changed to a pulsed cycle operation. This request has been evaluated, and considering the low contaminant level to be treated by the ISVE system, EPA will allow this change. An ESD will not be required for this minor modification of the ROD remedy.

EPA recently requested the PRPs to initiate Low-Flow sampling techniques for all future sampling, and to establish laboratory detection limits set to detect trace contaminants, namely vinyl chloride, TCE and benzene. This change was made to better characterize the the risk based chemical content at each monitoring well.

Institutional controls were part of the 1991 ROD remedy. It is unknown if these controls are legally binding. An evaluation of the status of institutional controls at the Site needs to be conducted, using current Five Year Review guidance. This analysis, complete with recommendations to guide future IC activity if required, will be conducted by ORC and completed by the end of the 2005 fiscal year.

#### **Protectiveness Statement:**

The remedy is currently protective of human health and the environment, and was constructed in accordance with the ROD and ESD. The remedial actions have eliminated human contact and exposure. However, in order for the remedy to be protective in the long-term, groundwater must be restored to clean-up standards.



## **Five-Year Review Report**

### **I. Introduction**

#### The Purpose of the Review

The purpose of a statutory five-year review is to evaluate whether a completed remedial action remains protective of human health and the environment at sites where hazardous waste remains on-site at levels that do not allow for unlimited use and unrestricted exposure. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues found during the review, if any, and identify recommendations to address them.

#### Authority for Conducting the Five-Year Review

U. S. EPA is preparing this Five-Year Review pursuant to CERCLA Section 121(c) and the National Contingency Plan (NCP). CERCLA Section 121(c) states:

*If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgement of the President that action is appropriate at such site in accordance with section 104 or 106, the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

U.S. EPA interpreted this requirement further in the NCP; 40 Code of Federal Regulations (CFR) Section 300.430(f)(4)(ii) which states:

*If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for the unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

#### Who Conducted the Five-Year Review

Mr. Kenneth Glatz, Remedial Project Manager, U.S. EPA Region 5, performed this five-

year review. The Five-Year Review was based, in part, on the ongoing oversight of monitoring activities at the Site from the start of the remedial action to present, and the interpretation of that data. In addition the Project Manager reviewed documents, including the ROD, SOW, ESD, PCOR, Construction Completion Report and results of supplemental studies conducted at the Site. U.S. EPA completed this Five-Year Review based upon the information obtained from these sources and activities.

#### Other Review Characteristics

This is the first five-year review for the Thermo Chem Site. The triggering action for this review is the date the Remedial Action Implementation Report was signed, March 8, 2000.

## **II. Site Chronology**

<u>Event</u>	<u>Date</u>
NPL RP Search	September 1985
NPL Listing	June 1986
Community relations Plan	July 1987
Consent Order	September 1987
Removal	December 1988
AOC	September 1989
Special Notice Letters	January 1990
Public Comment	July-September 1991
ROD	September 1991
Removal	September 1991
RI /FS Report	July 1991
CA	September 1996
PRP RD	August 1997

Construction Completion	March 1999
PRP RA	March 2000
ESD	September 2002
PCOR	September 2002

### **III. Background**

#### Physical Characteristics

The Site is located at 4331 and 4321 Evanston Road, Egelston Township, Michigan, approximately five miles east of the City of Muskegon and consists of approximately nine and a half acres of land on the south side of the road. This land formally housed the Thomas Solvent Company and Thermo Chem, Inc. facilities. The Thomas Solvent property covered approximately one and one-half acres in the northwest corner of the Site. The Thermo Chem, Inc. property covered the remaining eight acres. Thermo Chem, Inc. operated a solvents reprocessing and recovery facility and the Thomas Solvent Company operated a bulk solvents storage and distribution facility.

The Site is located in the Glacial Lake Plain physiographic unit. The Site is nearly level from north to south with an average elevation of approximately 655 feet above sea level. The changes in physical features at the Site are the result of clearing and construction activities. There is no natural surface drainage on the Site because of the nearly level land surface and the ability of the sandy soils to allow water to seep through them. Surface soil consists primarily of medium-to fine-grained sand. The only substantial surface water body in the area is Black Creek, which forms a broad and flat wetland with standing timber. Black Creek is located south of a twenty eight foot steep slope that defines the Black Creek flood plain valley. Black Creek flows to Mona Lake which discharges into Lake Michigan. Some of the areas around Black Creek lie within the 100-year flood plain area.

Two principal aquifers were identified during the Remedial Investigation and Technical Assistance Study at the Site. The upper unconsolidated, unconfined aquifer varies in thickness from 20 feet in the northeast area of the Site to 55 feet in the southwest portion of the Site. The groundwater table lies from 17 feet below the ground surface in the northeast to 32 feet below the surface in the southwest. The upper unconsolidated deposits are predominantly medium to fine grained sand. The upper and lower aquifers are separated by a discontinuous layer of clay. The deeper confined/semi-confined aquifer is located beneath the silty-clay layer. It varies in thickness from 61 feet to 116 feet. The deepest penetrated sediments are glacial tills.

### Land and Resource Use

The area surrounding the Site is semi-rural and is comprised of residential areas, light manufacturing, commercial buildings and undeveloped woodland.

The nearest population centers to the Site are two mobile home parks located about one-half mile west on Evanston Road that have a total of 594 lots. The nearest single-family residence is located immediately adjacent to the west of the Site has been sampled annually since 1986 by MDNR, and three residential wells on Mill Iron road have been sampled by MDNR (now MDEQ) since the late 1990s, with no concerns observed.

There is no designated Michigan State Significant Habitat, or historic landmark site directly or potentially affected. There is a potential for endangered species in close proximity to the Site, however none have been documented. Black Creek is designated as a trout stream by the State of Michigan. Black Creek is used for recreational purposes.

Two other Superfund sites are located near the Site. The SCA Independent Landfill Superfund Site is located approximately 300 feet south of Black Creek, and the Bofors Nobel Superfund Site is located approximately one and a quarter miles east of the Site. Both Sites border Black Creek.

### History of Contamination

Thermo Chem, Inc. operated as a solvent and chemical waste reprocessing, refining, and incineration facility from 1969 until August 1980. Solvents, paint wastes, and antifreeze received at the Site were distilled to regenerate usable solvents. Unrecoverable materials reportedly were incinerated on-site, as were distillation still bottom sludge and residues. Wastewater generated from the distillation and equipment-cleaning process was discharged into a series of three interconnected lagoons. The northern-most lagoon was lined with clay and the other two lagoons were unlined.

The Thomas Solvent Co. operated from 1961 to October 1986 as a licensed industrial waste hauler, and hauled hazardous waste to its subsidiary, Thermo Chem, Inc., for reprocessing. The Thomas Solvent Co. also acquired the recycled material from Thermo Chem, Inc. to return to its customers. Sixteen underground storage tanks with a capacity totaling 104,000 gallons were located on the Thomas Solvent Co. property and were used to store raw materials and these recycled materials. The Thomas Solvent Co. hauled over 200 different chemical blends to Thermo Chem, Inc. for reprocessing. Some of these chemicals were designated as hazardous waste according to the Resource Conservation and Recovery Act (RCRA) (40 CFR 261 Subpart C and D). At least 3,500 drums were stored on the Thermo Chem, Inc. and Thomas Solvent Co. properties during the time the two companies were in operation. There were no physical barriers separating these two adjacent properties whose ownership and operations were intertwined.

U.S. EPA identified a list of chemicals of concern for the Site. The risk assessment focused on health and environmental effects resulting from exposure to these chemicals.

1,1-Dichloroethene	Toluene
Total 1,2-Dichloroethene	xylene
Chloroform	bis(2-Ethylhexyl)phthalate
1,2 Dichloroethane	Napthalene
1,1,1-Trichloroethane	Arsenic
Trichloroethene	Chromium
Benzene	4,4' DDT
Tetrachloroethene	

These contaminants were detected in both groundwater and soils at the Site.

#### Basis for Taking Action

U.S. EPA determined that hikers and hunters who might accidentally swallow Site soil, inhale blowing dust, or inhale evaporating vapors from the soil might experience an excess cancer risk of two additional cases for every 1,000 people exposed to the contamination. The Hazard Index associated with such exposure was 500, indicating a strong likelihood that exposure would cause harmful non-cancerous health effects as well. These effects might include nerve damage resulting from exposure to arsenic and central nervous system depression from exposure to tetrachloroethene.

#### Initial Response

A soil investigation conducted by MDNR on December 10, 1984 at the Thermo Chem, Inc. property indicated the presence of: 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, 4,4' DDT, 1,2-dichloroethene, 1,2-dichloroethane, toluene, ethylbenzene, and xylenes. An investigation at the Thomas Solvent Co. portion conducted by MDNR on April 30, 1985 indicated that the soil was contaminated with most of these contaminants as well. Similar compounds also were detected in the groundwater during the 1985 investigation. Former Thomas Solvent Co. and Thermo Chem, Inc. employees indicated that sludge occasionally was buried on the properties and chemical spills frequently occurred at the Site. Based on the historical documents and statements from former employees, it was determined that F001-F005 solvent wastes were disposed of at the Site, which are identified as hazardous wastes under U.S. EPA's federal regulations promulgated pursuant to the RCRA, 42 U.S.C. 6901, *et seq.* U.S. EPA determined that groundwater contamination detected both beneath and downgradient from the Site was a result of contamination sources at the Thermo Chem, Inc. and Thomas Solvent Co. properties. Operations at the two properties had contaminated the groundwater in the shallow and deep aquifers. Suspected sources of contamination included the three inter-connected lagoons located in the central processing area and sludges disposed at the Thermo Chem, Inc. property, the underground storage tanks at the Thomas

Solvent Co. property, and spills throughout the Site.

The Thermo Chem, Inc. property was proposed for inclusion on the NPL in October of 1984. The Site was placed on the NPL in June 1986. A Consent Order was signed on September 21, 1987, by U.S. EPA and parties identified by U.S. EPA as being potentially responsible (PRPs) for the contamination problems at the Site. In the Consent Order, the PRPs agreed to conduct a RI/FS at the Thermo Chem, Inc. property to determine the nature and extent of contamination at the property, and identify methods to correct these problems. The PRPs began investigative activities in April 1989.

The Consent Order provided that the PRPs would not be required to conduct a RI/FS at the adjacent Thomas Solvent Co. property. However, during the RI/FS at the Thermo Chem, Inc. portion of the Site, it was discovered that contamination was coming from the Thomas Solvent Co. property. Therefore, U.S. EPA conducted a Technical Assistance Study to determine the nature and extent of contamination on the Thomas Solvent Co. property. U.S. EPA's investigation of contamination at the Thomas Solvent Co. property was completed in August 1990, and the final report of U.S. EPA's conclusions was completed in March 1991. The results of the investigation at the Thomas Solvent Co. property and the Thermo Chem, Inc. property indicated that the contamination releases at Thomas Solvent Co. appeared to be one source of the groundwater contamination identified in the Thermo Chem NPL listing. Accordingly, the Thermo Chem Site includes both the Thomas Solvent Co. property and the Thermo Chem, Inc. property. The Remedial Investigation indicated that groundwater flows south-southwest toward Black Creek.

Concurrent with investigation activities at the Thermo Chem, Inc. and Thomas Solvent Co. properties, an emergency removal of drums and materials containing hazardous waste was conducted by U.S. EPA at the Thermo Chem, Inc. property from September 1988 until December 1988. The removal action was taken to reduce the threats posed to public health by the presence of the chemicals and drums at the Site. The chemicals were stored in the laboratory building, and the drums were found in buildings throughout the Site. Buildings at the Site were unsecured. U.S. EPA also sampled the insulation materials from buildings and tanks for the presence of asbestos material. Results indicated that the insulation material did not contain asbestos.

U.S. EPA also conducted emergency removal activities in April 1991. During the investigation at the Thomas Solvent property, pure solvent LNAPL was discovered approximately 100 feet downgradient of the underground Thomas Solvent storage tank farm. U.S. EPA inspected these underground storage tanks and found that some contained residual solvents and had vent pipes which could not be secured. U.S. EPA determined that these tanks could pose an imminent and substantial endangerment to public health or welfare or environment because of the potential for explosion and threat of release from the tanks. The 16 underground storage tanks on the Thomas Solvent Co. property and their contents were removed and taken off-site for disposal by U.S. EPA.

## **IV. Remedial Actions**

### Remedy Selections

U.S. EPA separated the study of contamination at the Site into two separate areas, OU1 and OU2. OU1 would focus on contaminated soil, sludge and groundwater at the Site, up to the point where groundwater discharged into Black Creek. OU2 would address contamination problems in Black Creek, i.e., surface water, sediment, plants and living organisms, and groundwater south of Black Creek. The Operable Unit approach was agreed upon after discussions between U.S. EPA and MDNR during the RI.

### Operable Unit I (OU1)

The final RI Report for OU1 was completed in May 1991. A FS Report was finalized in July 1991. U.S. EPA identified contaminated groundwater, soil, and sludge as potential risks to human health and the environment. Contaminated soil at the Site was considered to be the principal threat. To address these risks, U.S. EPA developed the following remedial objectives for OU1 based on the data obtained during the Remedial Investigation:

- 1) Reduce or minimize direct human and environmental contact with contaminated soil through inhalation and ingestion;
- 2) Reduce or minimize the release of contaminants in soil and sludge to the groundwater; and
- 3) Restore groundwater so that contamination levels meet appropriate health standards, and stop the flow of contaminated groundwater to Black Creek.

The 1991 OU1 Source Control ROD consisted of:

#### Phase I :

- \* Decontamination, demolition, and off-site disposal of all on-site buildings, including the laboratory, process buildings, a warehouse, an incinerator, and all above-ground storage tanks.
- \* Excavation and off-site incineration of Group 1 and 2 soils with contamination above Michigan Act 307 Type A or B standards.

Phase II:

- \* Groundwater from the shallow and deep aquifers will be extracted and treated to Michigan Act 307 Type A or B standards using filtration, air stripping, metal precipitation, and pH adjustment. The emitted gases will be carbon treated to meet State air quality standards. The carbon will be regenerated or disposed of off-site in accordance with LDRs. The treated groundwater will be discharged to Black Creek under the substantive requirements of the NPDES.

Phase III:

- \* In-situ vapor extraction (ISVE) for all Site soils to meet Michigan Act 307 Type A or B standards, and the removal of the LNAPL source.

Additional OUI ROD requirements:

- \* Additional studies will be conducted at the Site to determine background soil concentration, the ability of some contaminants to leach to the groundwater, and the existence of other contaminated soil. Based on the results of these additional studies, more excavation and/or treatment may be necessary to meet Michigan Act 307 Type A or B standards.
- \* Institutional controls to be implemented to restrict future development of the Site to the extent necessary to implement and protect the remedy, and to safeguard human health and the environment during implementation of the remedy. These include Land Use restrictions and construction of a fence around the boundary of the Site.

Current Status of the 1991 ROD:

Phase I – Hot spot soil excavation with off-site treatment and disposal, asbestos and drum removal, Site demolition was complete in 1998.

Phase II – Groundwater Extraction Treatment System (GWETS). During the design studies for Phase II implementation two findings became apparent: 1) the groundwater treatment system could be substantially simplified. The filtration, air stripping, metal precipitation, and pH adjustment steps identified in the ROD were not necessary. GAC adsorption was selected for the groundwater treatment and there were no off-gases to be carbon treated. The treated groundwater is discharged to Black Creek under the substantive requirements of the NPDES; and 2) contaminant concentration found in the deep aquifer did not require treatment. Construction was complete in 1998 and operation started March 1999. Treatment is continuing until groundwater clean-up standards are met, and;



Phase III – In situ vapor extraction (ISVE) of Group 3 and 4 soils with on-site treatment to meet Michigan air discharge standards, and b; removal of free phase LNAPLs from the surface of the groundwater. Construction completed and operation started in August 1998. LNAPL removal is complete and the ISVE vapor treatment system will operate under a cyclic extraction process.

U. S. EPA approved the Remedial Implementation Reports for all three phases of the OU1 RD/RA project on March 8, 2000, and the Thermo Chem OU1 of the Site is currently in the Operational and Maintenance (“O&M”) phase of the RD/RA.

#### Operable Unit II (OU2)

The anticipated contamination problems in the Black Creek, including sediment, surface water, biota, and groundwater south of Black Creek, and the risks posed were the object of OU2. In preparation for OU2, U.S. EPA requested the PRPs to conduct additional field work to define groundwater contamination problems around Black Creek and the impact of the contamination on the Creek. The field work included installing approximately ten monitoring wells north of Black Creek, six monitoring wells south of Black Creek, and collecting seven sediment and surface water samples from Black Creek. Additionally, groundwater data was obtained and evaluations were conducted for ground water in the down gradient areas of OU2. The field work for these additional activities was initiated in July 1991. The OU2 investigative work was completed in April 2002.

The results of the OU2 RI/FS showed that the Site plume extends 1300 feet down gradient in the Black Creek flood plain. No human health or ecological risk associated with the Site residuals have been identified in the Black Creek or flood plain area. The evaluation of human health and ecological risks indicate that the VOC concentrations detected in the groundwater, surface water and sediment samples collected in the Black Creek flood plain would not affect recreational users or ecological receptors. The results of each exposure pathway are below Superfund’s acceptable cancer risk of  $1 \times 10^{-6}$  and below the acceptable hazard quotient and hazard index of 1 for noncarcinogens.

In November 2000, scientists at the U.S. EPA Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma (“U.S. EPA Kerr Lab”) concluded that the Site flood plain groundwater plume was limited to the area between MW-18 and OU2-MW4. The U.S. EPA Kerr Lab determined that the groundwater plume was controlled by a combination of natural biological degradation and discharge of contaminants to Black Creek. Monitoring data shows the transfer of ground water from the Site to Black Creek does not cause the surface water quality to exceed applicable water quality standards.

The U.S. EPA Kerr Lab also considered the effect on the Site plume of the operation of the Phase II Groundwater Extraction and Treatment System (GWETS) constructed as part of the OU1 remedy. Subject to confirmation that the Phase II GWETS contained the plume, the

U.S. EPA Kerr Lab concluded that the combination of natural flushing and natural biodegradation would reduce VOC concentrations in groundwater in the Black Creek flood plain to levels below the applicable Maximum Contaminant Limits (“MCLs”). The U.S. EPA Kerr Lab estimated that it would require six years of Phase II GWETS operations to restore the groundwater in the Black Creek flood plain to below cleanup standards.

In response to concerns raised by the Agency that there was limited evidence that the Phase II GWETS was achieving full capture of the plume, a Capture-Zone Analysis was completed in July 2002 using the Thermo Chem Groundwater Flow Model (July 31, 2000) developed by the U.S. EPA Kerr Lab (the “Kerr Lab Model”). The Kerr Lab Model was used to simulate the Phase II GWETS and determine if the GWETS was capturing the OU1 plume. The analysis simulated the flow pathlines and delineated the extent of capture of the GWETS. The Capture-Zone Analysis study results show that the simulated GWETS could capture the Site OU1 plume using five of the six existing extraction wells (well numbers EW1 – EW-6) as long as the system was operated at a minimum rate of 48.8GPM.

In responding to a concern advanced by MDEQ that the Kerr Lab Model did not accurately reflect Site conditions, EPA contracted Subterranean Research Inc., to conduct an assessment of groundwater capture requirements based on observed data (water level measurements and extraction rates). Water level measurements were interpreted and contour maps of head in the vicinity of the Site were developed. Hydraulic gradients were derived from the contour maps and used to draw particle tracks to the GWETS (paths that water particles would follow when moving through the aquifer). The particle tracks delineated the extent of hydraulic capture. Multiple water level measurement events were evaluated from October 1999 (at 58 gpm), and as recent as September 2004 (at 88.9 gpm). The study showed that at 49 gpm, hydraulic capture was not attained. Results were effected by the temporally varying regional hydraulic gradient as well as the distribution of pumping among the extraction wells. This study estimated that the minimum extraction rate to prevent contaminant flow into the Black Creek flood plain (at the measured hydraulic gradient measured in 2003) was 71 GPM, with the extraction rate distributed between the extraction wells as indicated in the chart on the attached particle capture flow path figures.

In September 2001 and March 2002, the final field investigations were performed in the Black Creek flood plain area to define the areal extent of the plume. Seven temporary well points were installed 500 feet west of OU2-MW4 and 150 feet south of OU2-MW3. The vertical aquifer sampling (VAS) results did not detect any VOCs above applicable MCLs.

In June 2002, a survey of local water wells was conducted up to a three mile radius of the Site. The closest wells are 430 feet up gradient of the plume and located on the northern Black Creek bluff. Groundwater in this area flows from the north (from the Black Creek bluff area) to the south (towards Black Creek). Sampling of these upgradient wells has not detected any VOCs. Natural processes are reducing levels of contamination in the Site

plume downgradient of the GWETS. The nearest down gradient domestic water well is located 0.5 miles from the western most edge of the Site plume.

### Significant Differences

Significant differences from the September 30, 1991 ROD are:

- 1) The first significant difference reflects a merger of the OU2 area into the OU1 area because no additional remedy is needed to cleanup the OU2 Area. U.S. EPA has determined it was appropriate to modify the original OU1 ROD to combine the requirements of OU1 and OU2 into OU1 ROD. The 1991 ROD states that “The contamination problems in the Black Creek, including sediment, surface water, biota, and groundwater south of Black Creek, and the risks posed thereby will be evaluated and addressed during OU2.” Supplemental studies conducted at the Site from 1995 through 2002 have demonstrated that there is no ecological or risk based levels of contamination in creek sediments, surface water or the groundwater south of Black Creek. After completing the plume delineation and observing the ongoing natural biodegradation processes in the Black Creek Area, U. S. EPA determined that it is unnecessary to maintain the operable unit separation at the Site. The remedy for OU1 is protective because it captures the Site VOC plume and prevents any further threat to Black Creek. Any residual VOC concentrations remaining in the Black Creek flood plain area will degrade naturally to levels below applicable MCLs without additional remedial action. The merger of OU1 and OU2 constitute a significant change to the remedy, but does not fundamentally alter the overall approach presented in the OU1 ROD. The remedy for OU1 is protective since the remedy effectively cuts off the VOC contamination from reaching Black Creek.
- 2) The second significant difference reflects changes to groundwater cleanup standards based on Michigan Part 201 Criteria. Only VOCs values have been updated since these compounds create the risk for the contaminated plume. The ROD selected a remedy that met Michigan Act 307 Type B Standards for groundwater, based on the Michigan Environmental Response Act (MERA), 1982 PA 307. In 1994, the State of Michigan enacted Part 201 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (“Part 201”), which, in relevant part, replaced the former Michigan Act 307 Type B Standards for groundwater. Part 201 cleanup standards constitute applicable or relevant and appropriate requirements under CERCLA that protect human health and natural resources. The U.S. EPA has determined that the current Part 201 cleanup standards for groundwater should be applied to the Site. Modifying the Michigan Act 307 cleanup standards to the Michigan Part 201 criteria allows an equally protective remedy for the Site based on currently available State guidance. The former Michigan Act 307 Type B groundwater cleanup values listed in the ROD and current groundwater cleanup values based on Part 201 are listed in Table 1. This change does not fundamentally alter the overall approach intended by the remedy set out in the ROD.

## Remedial Goals

The Remedial Action shall restore the plumes to: Drinking Water Standards listed in Table 1; a cumulative excess cancer risk below  $10^{-4}$ ; and a cumulative Hazard Index below one throughout the plume; and deed restrictions on the use of contaminated groundwater until groundwater goals have been met.

## System Operation and Maintenance

### ISVE System

The LNAPL source at the groundwater interface has been removed by the skimmer system, and the skimmer system has been shut down. Removal of the LNAPL source also reduced the ISVE feed stream contaminant concentration to very low levels. The PRPs have requested that the ISVE be operated on a pulsed cycle mode. The EPA has granted this request based on an evaluation of the low chemical content to the ISVE treatment system. An ESD is not required for this modification of the ROD remedy.

### GWETS System

O&M procedures are in place to remove bio-fouling on several of the extraction pumps and process lines. This allows the extraction rates to meet, or exceed, the design extraction rates and intercepts the flow of contaminant discharging into the Black Creek flood plain. Treatment vessel carbon is replaced when contaminant breakthrough is evident.

### Monitoring Well Systems

The monitoring program is currently under review by MDEQ and EPA. The PRPs are preparing an inventory of all monitoring data results, and the data will be statistically analyzed to indicate progress, or lack of progress, toward groundwater restoration goals. This inventory will also be used to establish future sampling requirements.

In the past sampling has been conducted with bailers, and detection limits set above typical trace contaminant levels. This was done to characterize total VOC sample content, rather than trace chemical content. EPA recently requested all future sampling be conducted using Low-Flow sampling techniques, with detection limits set to detect trace contaminants, namely vinyl chloride, TCE and benzene, to better characterize the risk based chemical content at each well.

## **V. Progress since the last Five-Year Review**

This is the first five year review for the Thermo Chem Site.

## **VI. Five-Year Review Process**

### **Administrative Components**

This Five-Year Review was based, in part, on the inspection conducted at the Site on November 17, 2004 by the Settling Defendants contractor, MDEQ and U.S. EPA Project Manager, results from O&M activities at the Site, and the analysis of the data contained in the monitoring reports. In addition the Project Manager reviewed documents, including the ROD, SOW, ESD, PCOR and results of supplemental studies conducted at the Site. U.S. EPA completed this Five-Year Review based upon the information obtained from these sources and activities.

### **Community Involvement**

Upon the signing of the Consent Order in September 1987, U.S. EPA held a 30-day public comment period. A press release was sent to all media and advertisements were placed in the Muskegon Chronicle.

A fact sheet was developed in June 1988 to announce and explain the RI process.

A Community Relations Plan was prepared for the Site in July 1989. This plan lists contacts and interested parties throughout the local and government community.

A public meeting was held on April 18, 1991 to explain the results of the Remedial Investigation and the plan to remove the underground storage tanks at Thomas Solvent Co. property. A fact sheet was developed in conjunction with this meeting. Advertisement were placed to announce the meeting and a press release was sent to all local media.

The RI/FS Reports and Proposed Plan for OU1 at the Site were released to the public in July 1991. The notice of availability of documents was published in the Muskegon Chronicle on July 8, 1991. Press releases were also sent to all local media. A public comment period was held from July 11, 1991 to September 9, 1991. In addition, a public meeting was held on July 16, 1991 to present the results of the RI/FS and the preferred alternative as presented in the Proposed Plan for the Site. All comments which were expressed verbally at the public meeting are addressed in the Responsiveness Summary of the 1991 ROD.

A press release was placed in the Muskegon Chronicle in early March, informing the public of the Five Year Process, and offering the opportunity for public comment.

Public interest has been low since the source removal was completed.

### Interviews.

No interviews were conducted in connection with this five year review.

### Site Inspection

An official Site inspection was conducted on November 17, 2004 hosted by the PRP's contractors. The ISVE and GWETS process equipment, monitoring wells and fencing were all in operating condition. Housekeeping in the GWETS was exceptional. Some minor repairs to the fence were being planned by the PRPs.

### Document and data review

The Project Manager reviewed documents, including the ROD, ESD, PCOR and data evaluation of the post monitoring events. U.S. EPA completed this Five-Year Review based upon the information obtained from these sources and activities. The documents and data reviewed in preparing this Five-Year Review are listed in the attachment entitled "List of Documents Reviewed".

## **VII. Technical Assessment**

**Question A: Is the remedy functioning as intended by the decision documents? YES**

### Remedial Action Performance

The remedy is protective of human health and the environment. The remedy implemented for the Site complies with the performance standards selected in the ROD, ESD and ARARs. Removal of soils, sludges, tanks, drums and process equipment from the lagoons and process area has removed the possibility of human contact with the source material; installation and operation of a groundwater soil vapor extraction system (ISVE), removed the free phase organic layer from the surface of the water table and has reduced the VOC content of these soils to low levels. The installation and operation of a groundwater extraction and treatment system (GWETS) has been effective in removing groundwater contamination. Institutional controls restrict use of contaminated groundwater until clean-up goals have been met.

The GWETS system is effectively treating the extracted groundwater to NPDES standards for discharge to Black Creek, and has intercepted the flow of contaminated groundwater to the Black Creek flood plain. Natural processes are in operation in the flood plain that are reducing risk based contaminants. Operation of the monitoring system is ensuring the Site is progressing toward Table 1 ground water restoration values. In June 2002, a water well survey was conducted inside a three mile radius of the Site. The closest wells are located on the northern portion of the Black Creek bluff, about 430 feet west of the southwest flowing plume. Modeling and well sampling show no impact to these residential wells, although one VOC was detected at a very low level in an Arlington Estate production well near the bluff.

Continued monitoring in the flood plain will insure that contaminants do not impact this well.

### System Operation and Maintenance

#### ISVE System

The LNAPL source at the groundwater interface has been removed by the skimmer system, and the skimmer system has been shut down. Removal of the LNAPL source also reduced the ISVE feed stream contaminant concentration to very low levels. The PRPs have requested that the ISVE be operated on a pulsed cycle mode. The EPA has granted this request based on an evaluation of the low chemical content to the ISVE treatment system. An ESD is not be required for this modification of the ROD remedy.

#### GWETS System

O&M procedures are in place to remove bio-fouling on several of the extraction pumps and process lines. This allows the extraction rates to meet, or exceed, the design extraction rates and intercepts the flow of contaminant discharging into the Black Creek flood plain. Treatment vessel carbon is replaced when contaminant breakthrough is evident.

### Monitoring Well Systems

An additional monitoring well cluster will be added in the spring of 2005 to better define the leading edge of the plume in the wetland. The Site monitoring well system contains plume centerline wells, sentinel wells (perpendicular to centerline wells), plume boundary wells and background wells (upgradient of the plume). These wells will be sampled using Low-Flow sample techniques starting in 2005. The monitoring program is currently under review by MDEQ and EPA. The PRPs are preparing an inventory of all monitoring data results, and if sufficient historical data is available it will be statistically analyzed to indicate progress, or lack of progress, toward groundwater restoration goals. This inventory will also be used to establish future sampling requirements.

In the past, sampling has been conducted with bailers, and detection limits set above typical trace contaminant levels. This was done to characterize total VOC sample content, rather than trace chemical content. EPA recently requested all future sampling be conducted using Low-Flow sampling techniques, with detection limits set to detect trace contaminants, namely vinyl chloride, TCE and benzene, to better characterize the risk based chemical content at each well.

### Implementation of Institutional Controls and Other Measures

Institutional controls are identified in the ROD remedy that restrict the use of contaminated groundwater for all uses until the groundwater meets the clean-up standards in Table 1.

Institutional controls restrict future development of the Site to the extent necessary to implement and protect the remedy, and to safeguard human health and the environment during implementation of the remedy. These include land use restrictions and construction of a fence around the boundary of the Site. It is unknown if these controls are legally in place.

The MDEQ contracted the local Health Department to monitor selected wells with potential contamination on an annual basis.

Fencing and warning signs are in place at the Site.

#### Update of the Drinking Water Criteria to MDEQ Part 201 Health Based Criteria

MDEQ Part 201 Residential Health Based Groundwater Criteria reflect concentrations in drinking water which are safe for long-term, daily consumption. Clean-up criteria for several chemicals have changed since the 1991 ROD, based on MDEQ part 201, Environmental Remediation, of the NREPA, 1994 PA 451, as amended (Part 201). Table 1 presents the ROD clean-up criteria. These cleanup criteria are the same as the Maximum Contaminant Levels (MCLs) of the Federal drinking water standards promulgated under the Safe Drinking Water Act 40 CFR 141. U.S. EPA has determined that the changes to the Cleanup Standards are protective of human health and the environment, and are acceptable changes to the ROD Cleanup Standards.

#### **Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy still valid? YES**

##### Changes in Exposure Pathways

There have been no changes in the potential exposure pathways at the Site since the implementation of the remedy for the Site. There have been no land use changes at the Site nor are any expected in the future.

##### Changes in Toxicity and Other Contaminant Characteristics

Neither the toxicity factors for the contaminants of concern nor other contaminant characteristics have changed in a way that could affect the protectiveness of the remedy.

##### Changes in Risk Assessment Methods

Standardized risk assessment methods have not changed in a way that could affect the assessment of the protectiveness of the remedy.



### Expected Progress Toward Meeting Remedial Action Objectives

The goal of this response action is to reduce risk from groundwater and soil contamination at the locations included in OUI and the ESD to acceptable human health standards of  $10^{-6}$  for cancer-causing contaminants and a hazard index of 1.0 for non-cancer causing contaminants, and applicable or relevant and appropriate standards. Progress is being made toward fulfillment of these goals.

### Changes in Standards and To Be Considered Criteria

There are no standards identified in the ROD which have been revised, no newly promulgated standards and no TBC used in selecting the cleanup levels at the Site that have changed and could affect the protectiveness of the remedy.

**Question C: Has any other information come to light that could call into question the protectiveness of the remedy? NO**

### Technical Assessment Summary

A Construction Quality Assurance Plan (CQAP) was prepared in conjunction with the remedial design to address the activities necessary to ensure compliance with the requirements of the remedy. The protocols contained in the CQAP were employed during construction to ensure that the treatment system would perform in accordance with the ROD and RD plans and specifications. Details of the procedures used to ensure the quality of the construction work are contained in the approved CQAP.

The groundwater monitoring program implemented during the Operation and Maintenance (O&M) phase was performed in accordance with the approved QAPP for O&M. The laboratories used for the analysis of the groundwater samples were determined to be acceptable for use by the U.S. EPA Region 5 Environmental Sciences Division based on previous laboratory audits. There have been no newly identified human health or ecological risks, impacts from natural disasters, or any other information that has been identified that could affect the protectiveness of the remedy for the Site.

### **VIII. Issues:**

The remedy for groundwater restoration has been in operation since 1999. Results of the monitoring data, although not conclusive, indicate progress toward achieving groundwater clean-up goals. Initially the GWETS upper aquifer extraction/treatment system was not completely capturing the plume, allowing contaminants to flow into the Black Creek floodplain. With improved preventative maintenance of the pumps, and periodic flushing of the extraction pumps and process lines, the extraction rates are now high enough to achieve hydraulic capture of the contaminated plume, intercepting the flow of contaminated groundwater to the wetlands. Data also suggests that the residual contamination in the

wetlands, down gradient of the GWETS, is being reduced by natural processes. However both of these observations need to be supported by continued hydraulic and chemical monitoring.

There is some concern, based on the distance between the monitoring wells in the wetlands, that the leading edge of the wetlands plume may not be adequately monitored.

Monitoring data collected during 1998 and 1999 sampling events, and during supplemental studies by EPA KERR lab personnel from Ada, Oklahoma, indicated that there may be deep aquifer contamination which is not being captured by the GWETS.

There are residential wells in the vicinity of the Site that have the potential of being impacted by the plume, which are only being monitored for VOCs on an annual basis.

In the past, sampling has been conducted with bailers, and laboratory detection limits set above typical trace contaminant levels. This was done to characterize total VOC sample content, rather than trace chemical content.

## **IX. Recommendations and Follow-up Actions:**

The adequacy of hydraulic capture of contaminated groundwater by the GWETS will be evaluated on a quarterly basis by the interpretation of observed water levels and the analysis of groundwater flow directions and flow rates, to show whether the GWETS is preventing the flow of contaminants to the Black Creek floodplain. The model will be used for this analysis. Two groundwater "capture" figures are attached to this report showing paths that water particles would follow when moving through the aquifer. The Subterranean Research Inc. analysis will be performed for each groundwater monitoring event, and extraction rates adjusted as required to maintain capture of the contaminated plume.

Monitoring data will be statistically analyzed when data becomes available to show the progress/lack of progress toward groundwater clean-up goals. In order to insure that the GWETS continues to operate as designed, and to address any detrimental change in the natural processes being observed at the Site, more monitoring wells and additional remedial activity will be considered if the results from a statistical evaluation at any monitoring well downgradient of the GWETS does not indicate a "Significant better" or "Significantly Decreasing Trend". Historical monitoring data is currently being consolidated as a starting point for this analysis. A revised monitoring program will be structured to rectify any deficiencies of the historical data necessary to perform the statistical analysis.

One additional monitoring well cluster is currently being installed in the Black Creek floodplain, and will be added to the monitoring program to improve the monitoring at the down gradient western edge of the Black Creek floodplain plume. All contaminants of concern were below analytical detection levels for the VAS phase of the well installation.

Hydraulic and chemical monitoring at the Site will continue in both the upper and lower aquifers until the groundwater meets the clean up standards shown in Table 1 throughout the plume. The monitoring schedule for the lower aquifer may be revised downward if the results of chemical monitoring in the lower aquifer indicates that the VOC content is below risk based values.

The PRPs have requested that the ISVE vapor extraction system be changed to a pulsed cycle operation. This request has been evaluated, and considering the low contaminant level to be treated by the ISVE system, EPA will allow this change. An ESD will not be required for this minor modification of the ROD remedy.

EPA recently requested the PRPs to initiate Low-Flow sampling techniques for all future sampling, and to establish laboratory detection limits set to detect trace contaminants, namely vinyl chloride, TCE and benzene. This change was made to better characterize the the risk based chemical content at each monitoring well.

Institutional controls were part of the 1991 ROD remedy. It is unknown if these controls are legally binding. An evaluation of the status of institutional controls at the Site needs to be conducted, using current Five Year Review guidance. This analysis, complete with recommendations to guide future IC activity if required, will be conducted by ORC and completed by the end of the 2005 fiscal year.

#### **X. Protectiveness Statement:**

The remedy is currently protective of human health and the environment, and was constructed in accordance with the ROD and ESD. The remedial actions have eliminated human contact and exposure. However, in order for the remedy to be protective in the long-term, groundwater must be restored to clean-up standards.

#### **XI. Next Five-Year Review**

The next five year review is due March 2010, five years after signature of the first five year review.

### List of Documents Reviewed

- 1     Record of Decision, Thermo Chem Inc. Site, Muskegon, Michigan U.S.EPA, September 30, 1991
- 2     Technical Memo #7 Prepared for Thermo Chem Inc. Site Group by Arcadis March 8, 2000.
- 3     Explanation of Significant Difference, Thermo Chem Inc. Site, Muskegon, Michigan, U.S.EPA, September 17, 2002
- 4     Preliminary Close Out Report, Thermo Chem Inc. Site, Muskegon, Michigan U.S.EPA, September 17, 2002

Figure 1     Site Map

Figure 2     Groundwater Plume 2002

Table 1     Cleanup Standards

\*January 2004 Groundwater Particle Trace

\*June 2004 Groundwater Particle Trace

\* Note that in the June 2004 example, plume breakthrough is shown between EW-2 and EW-3 (8 gpm actual vs 10 gpm design), as indicated by the brown arrows (the blue lines are groundwater iso-contour lines), even though the total extraction rate is 95.4 gpm, well above the design pumping rate of 71 gpm.

Table 1  
Cleanup Standards

Compounds  VOCs	1991 ROD cleanup values ug/l	2002 ESD* cleanup values ug/l
Acetone	500	730
Benzene	1	5
Carbon Tetrachloride	0.3	5
Chloroform	6	100
1,1-Dichloroethane	700	880
1,2-Dichloroethene	70	(cis-DCE) 70 (t-DCE) 100
1,1-Dichloroethene	7	7
1,2-Dichloroethane	0.4	5
2-Butanone	400	2200
1,1,1-Trichloroethane	117	200
1,1,2-Trichloroethane	0.6	5
Tetrachloroethane (1,1,2,2)	0.2	8.5
Trichloroethene	3.0	5

Tetrachloroethene	0.7	5
Toluene	100	140
Ethylbenzene	30	18
Styrene	1	80
Xylenes (total)	59	35
Vinyl chloride	No value assigned	2
1,2 Dichlorobenzene	7	16
2-methylphenols	40	71
Naphthalene	29	13
2-methylnaphthalene	10	260
Bis (2-ethylhexyl) phthalate	2	6
Pentachlorophenol	0.3	1
Inorganic Compounds		
Aluminum	50 – 200	300
Arsenic	0.02	50
Cyanide	4	20
Iron	300	2,000
Zinc	80	2,400

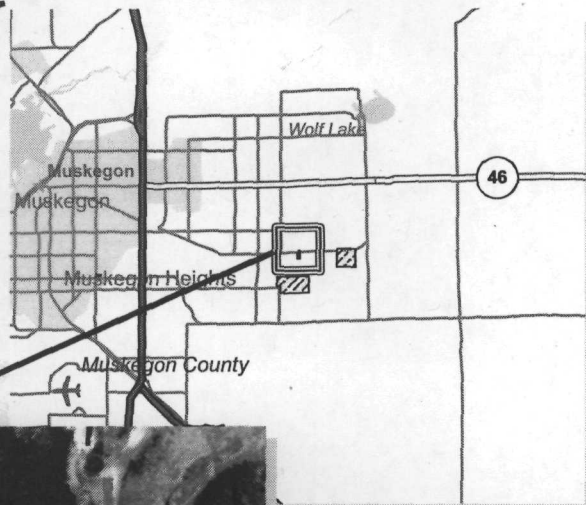
\* Most restrictive of the following: National Primary Drinking Water Regulations as of May 31, 2001 (MCLs); MDEQ Part 201, Act 451, Health Based Residential Drinking Water Standards as of June 7, 2000; Part 31, Act 451, Water Quality Values established under Rule R 323.1057 as of June 10, 2002.

# Thermo Chem Site

## 1) State



## 2) Muskegon County



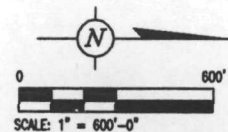
## 3) Thermo Chem Site



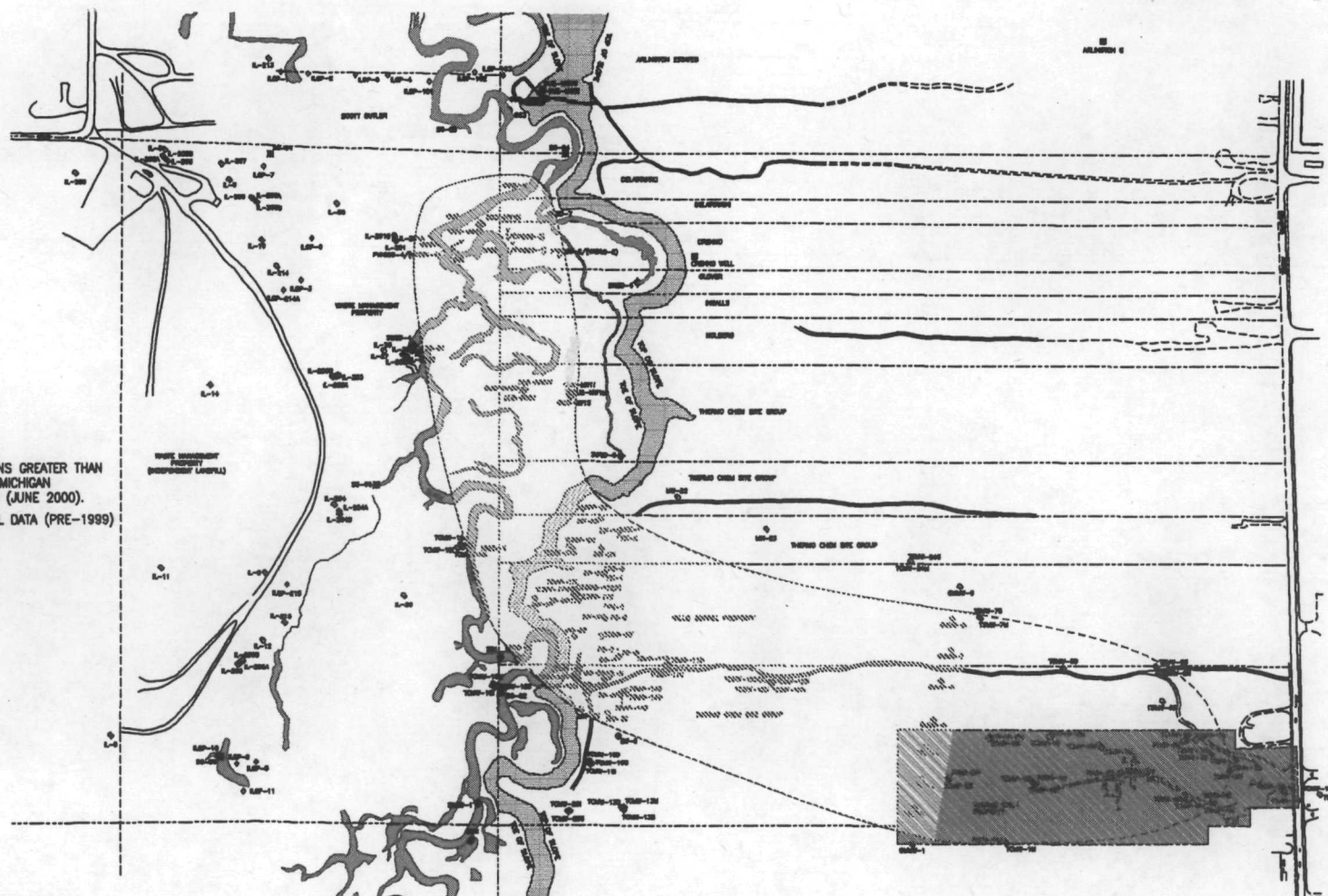
Figure 1

Plot created by Andrea Porter U.S. EPA Region 5 on 2/7/2005



**LEGEND:**

- ◊ MONITORING WELL LOCATION
  - ▼ PIEZOMETER
  - ◆ SURFACE WATER MONITORING LOCATION
  - ⊠ THERMO CHEM STAFF-GAUGE LOCATION
  - INDEPENDENT LANDFILL STAFF-GAUGE LOCATION
  - ⊙ EXTRACTION WELL LOCATION
  - ◇ VERTICAL AQUIFER SAMPLING LOCATIONS
  - VOC VOLATILE ORGANIC COMPOUNDS
  - ⊠ RESIDENTIAL WELL LOCATION
  - PROPERTY BOUNDARY
  - THERMO CHEM SITE BOUNDARY
  - THERMO CHEM SITE
- THERMO CHEM SITE RELATED VOC CONCENTRATIONS GREATER THAN EITHER THE MICHIGAN ACT 307 TYPE B OR THE MICHIGAN PART 201 RESIDENTIAL DRINKING WATER CRITERIA (JUNE 2000).
- GROUNDWATER DELINEATION BASED ON HISTORICAL DATA (PRE-1999)

**NOTES:**

1. ALL WELLS LOCATED OUTSIDE THE VOC PLUME ARE EITHER NON-DETECT, BELOW THE CRITERIA, OR HAVE NO DIRECT RELATIONSHIP TO THE THERMO CHEM PLUME.
2. SAMPLING LOCATIONS ILGP-101, ILGP-102 & ILGP-103 INSTALLED FEBRUARY/MARCH 2002.

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**THERMO CHEM SITE**

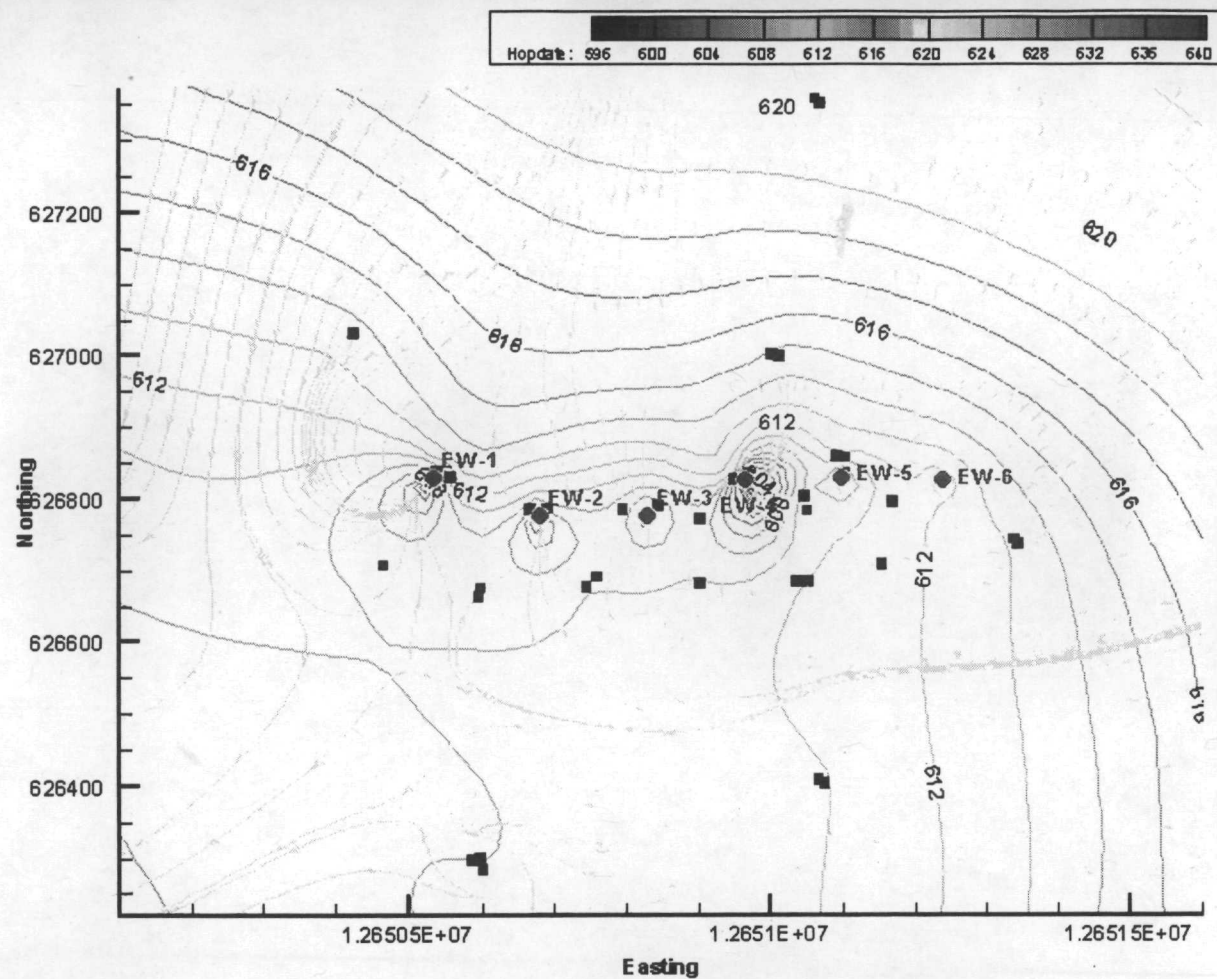
**THERMO CHEM**  
**GROUNDWATER DELINEATION**  
**MUSKEGON, MICHIGAN**

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		Project Number	Figure
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**January 2004:**

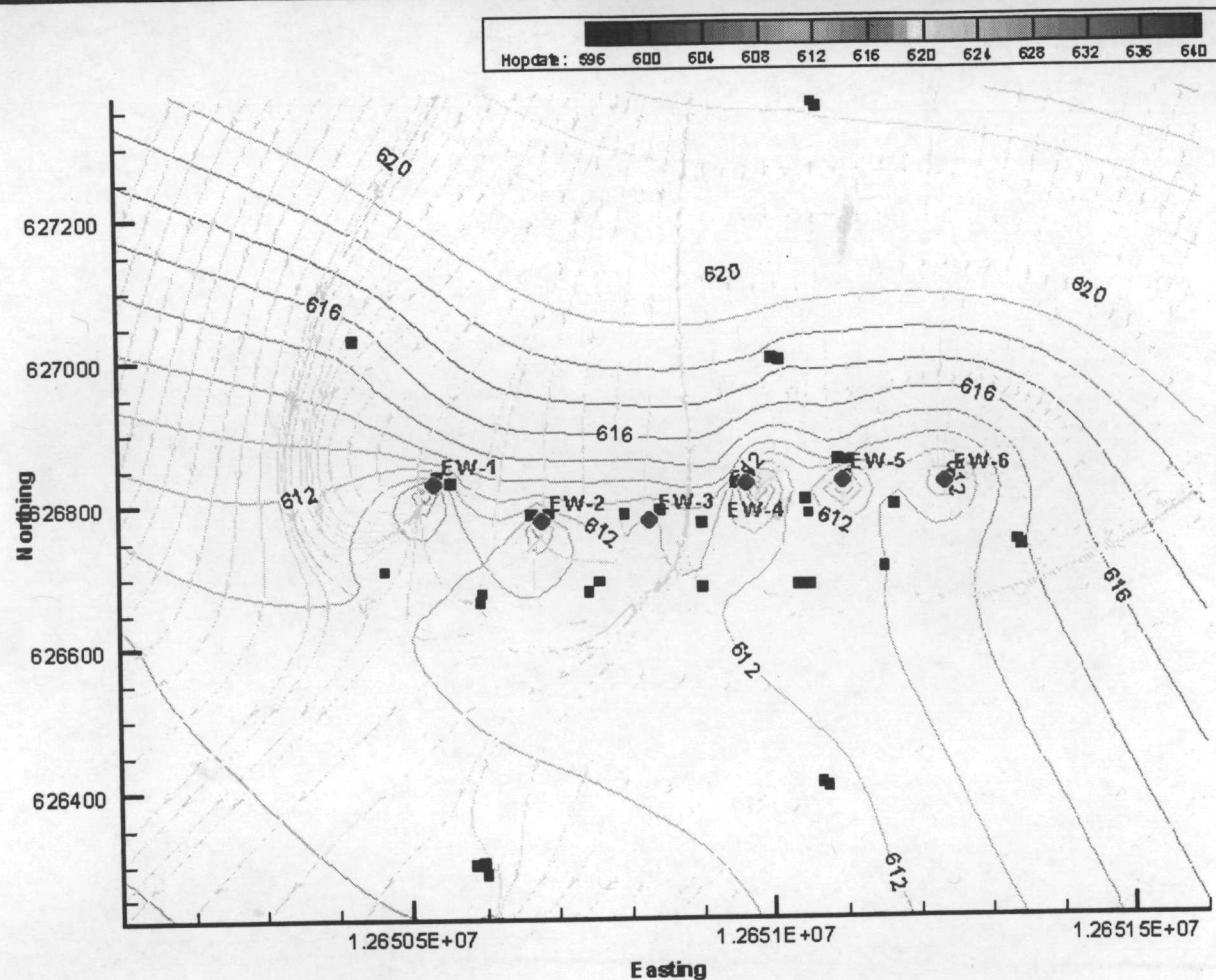
Thermo Chem - Jan 2004 Data | Run on: | 18 Mar 2005 |



Pumping Well	PRP Goal Rate (gpm)	Actual Rate (gpm)
EW-1	20	25.3
EW-2	10	12.1
EW-3	10	13.1
EW-4	8	13.5
EW-5	15	14.5
EW-6	8	13.0

**June 2004:**

Thermo Chem - June 2004 Data | Run on: | 18 Mar 2005 |



Pumping Well	PRP Goal Rate (gpm)	Actual Rate (gpm)
EW-1	20	29.0
EW-2	10	15.7
EW-3	10	8.3
EW-4	8	13.4
EW-5	15	15.5
EW-6	8	13.4